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Operating Experience Summary

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May 13 — May 25, 2000

Summary 2000-10

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May 13 through May 25, 2000

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EVENTS

1. FALLING PIPE FALLS NEARLY HITS OFFICE WORKER

On May 8, 2000, at Savannah River, an abandoned cast iron vent pipe fell through an acoustic office ceiling as subcontractor workers engaged in roofing repair activities. Facility management stopped all roofing repair work, contacted engineering to remove the fallen vent pipe, inspected the area for other potential hazards, and held a critique meeting to determine cause and discuss corrective actions. Although the falling pipe nearly struck an office worker, there were no injuries associated with this event. Failure to perform facility walkdowns can result in personnel injury or equipment damage. (ORPS Report SR-WSRC-REACC-2000-0002)

The 4-inch diameter by 8-foot long vent pipe was abandoned in the mid-980s when the facility was converted to an administrative area. Investigators determined that the subcontractor at that time sealed the bottom end of the "T" shaped vent pipe and left the top of the pipe open to the elements, and that only caulking material supported the pipe at the pipe-roof interface. They determined that the roofing subcontractor in May 2000 used roof removal equipment that caused extreme vibration and contributed to the occurrence. Investigators determined that the vent pipe's open end allowed rainwater to enter and added stress to the existing pipe supports when the rainwater collected at the pipe's sealed end. Investigators determined that the pipe and the rainwater it contained weighed approximately 100 pounds when it fell through the acoustic ceiling and into the office space.

Facility management will implement the following corrective actions.

- Before decontamination and decommissioning work is started, crawl spaces will be inspected carefully for hazards.
- Facility management will ensure that an adequate safety walkdown is completed before and after decontamination and decommissioning workers perform their jobs.

EH engineers identified the following events involving falling piping, equipment, or other building materials.

- Operating Experience Summary 99-10 reported that on February 18, 1999, at the Savannah River Laboratory Technical Area, a sludge collector containing a 25-liter sample of radioactive wastewater fell from its transfer cask as workers were attempting to lower it into a cell. The 150-pound sludge collector fell through an open access plug in a cell roof mezzanine and approximately 15 feet into a waste box when a winch cable failed. The accident did not result in personnel injury, damage to the cell or the sludge collector, or release of contamination. (ORPS Report SR--WSRC-LTA-1999-0007)
- Operating Experience Summary 99-06 reported that on April 23, 1998, at the Oak Ridge Y-12 Site, a facility employee was struck by Sheetrock and ceiling tiles that fell 10 feet onto an occupied cafeteria table. Facilities management personnel determined that an improperly repaired steam had been leaking through a steam trap in the overhead piping, causing water to accumulate in the ceiling. The accumulated water weakened the ceiling, resulting in the falling Sheetrock and tiles. (ORPS Report ORO--LMES-Y12SITE-1998-0018)
- Operating Experience Summary 98-39 reported that on September 14, 1998, at the Oak Ridge East Tennessee Technology Park, workers were performing asbestos abatement activities when an 8-foot section of 3-inch diameter metal pipe broke loose from its overhead hangers and fell approximately 20 feet into an area that was not isolated by a barrier. (ORPS Report (ORO--BNFL-K33-1998-0008)

KEYWORDS: vent pipe, fallen pipe, abandoned pipe, safety walk-down

FUNCTIONAL AREAS: Industrial Safety, Hazards and Barrier Analysis

2. MULTIPLE FILTER PLENUM SYSTEM PROBLEMS

EH engineers reviewed five recent filter plenum system occurrences.

On April 25, 2000, at Rocky Flats, a seismically qualified filter deluge panel entered a supervisory alarm mode and facility management declared it inoperable. The panel had been installed recently during a plant-wide fire security upgrade. Facility management declared this occurrence a performance degradation of a safety class structure or components. There were no injuries associated with this event. (ORPS Report RFO--KHLL-371OPS-2000-0029) On December 25, 1999, at Rocky Flats, a filter plenum deluge panel received a supervisory alarm that failed to reset. The site fire department issued an impairment tag and declared the filter plenum inoperable until the alarm could be repaired. Facility management suspended all work involving spark, heat or flame. The fire systems engineer contacted the panel manufacturer concerning the unexplained alarms and continues to wait for a response. There were no injuries associated with this event. Faulty filter plenum deluge panels can render filter deluge systems inoperable and not available when required, and can lead to personnel injury and facility damage. (ORPS Report RFO--KHLL-371OPS-1999-0082)

On January 5, 2000, Rocky Flats plant review committee discovered that a fire panel was not connected to an emergency power system and speculated that its batteries could only be credited for 18 hours. The National Fire Protection Association and the National Fire Alarm Code stipulate a 24-hour minimum life for backup batteries. Fire protection engineering performed calculations and determined that the batteries were adequately sized to provide 24 hours of standby operation and 5 minutes of alarm current. Investigators determined that the associated safety evaluation report acceptance criteria did not identify any surveillance that could verify the adequacy of battery size to sustain operation for 24 hours. There were no injuries associated with this event. (ORPS Report RFO--KHLL-771OPS-2000-0001)

On February 15, 2000, a Rocky Flats main exhaust plenum fire panel battery failed a load test. Configuration control authority established a limiting condition of operation until maintenance personnel could replace the defective battery. The battery failed the load test when it could not maintain a minimum discharge current. There were no injuries associated with this event. (ORPS Report RFO--KHLL-771OPS-2000-0007)

On February 29, 2000, a flow reversal and contamination spread occurred in Rocky Flats building 371 when an air operated valve stuck while personnel switched filter plenums during a pressure indicating controller test. Although personnel corrected the problem by manually assisting the air-operated valve to effect ventilation system balance, the correction was temporary and the differential pressure dropped again. When personnel engaged a backup exhaust fan they were able to restore and maintain the required differential pressure. The root cause of this event was inadequate work control. Personnel failed to recognize the consequences of proceeding with the evolution and the impact it could have on the facility. Personnel should have stopped work and notified the shift manager when the exhaust fan failed to maintain the required differential pressure. There were no injuries associated with this event. (ORPS Report RFO--KHLL-371OPS-2000-0012)

These events underscore the need for continued safety management attention to ventilation system operation, design, and maintenance. The 6-month delay in response from the manufacturer and continued compensatory actions are an example of conditions which force facilities into extended periods of temporary work-arounds. Such conditions require even more safety vigilance to ensure no degradation in protection.

KEYWORDS: filter plenum deluge, fire, alarm, air-operated valve, flow reversal

FUNCTIONAL AREAS: Industrial Safety, Fire Protection

3. SCISSORS LIFT BREAKS FIRE SUPPRESSION SYSTEM PIPE

On May 8, 2000, at Oak Ridge, two workers were cutting piping in an overhead when the scissors lift they were using contacted and broke a fire suppression system drain line. Most of the water exited the building via a floor drain that discharged into a nearby stream. A small amount of water escaped the building to a vegetated area. Surface radioactive contamination on the building floor was not entrained in the flow, according to measurements at the outfall of the storm sewer drain. There was no personnel contamination or injury. Violation of procedures can lead to improper discharge of contaminated fluids and worker contamination, during routine work activities. (ORPS Report ORO--DRS-ETTP1420-2000-0004)

Investigators determined that two workers were cutting piping out of an overhead while standing in a mobile scissors lift that was rolled laterally while elevated. The worker operating the lift lowered the platform before returning the lift to its original position. The lift support arm contacted a lateral run of a two-inch drain line for the fire suppression system. The drain line separated at a threaded elbow in an attached vertical riser. Half the rusted threads remained in the elbow. Less than 20 gallons of water escaped the building, flowing under a roll-up door, spreading across an asphalt pad north of the building and onto a vegetated area. Swipes taken from the asphalt pad indicated no activity above minimum detectable activity. Most of the water escaped the building down a floor drain near the roll-up door, until area personnel plugged the drain. Water samples from the stream where this sewer storm drain discharged indicated no activity above minimum detectable concentrations. The East Tennessee Technology Park (ETTP) Fire Department responded and secured the pipe leak several minutes later. Approximately 65 gallons of standing water were vacuumed into 55-gallon drums.

Several issues and corrective actions arose from this event:

- The two workers who incorrectly operated the scissors lift in violation of procedures were disciplined. Documented training will be provided on operation of lift equipment for all involved workers. The Director of Regulatory Affairs for the decontamination and decommissioning (D&D) contractor proposed documented remedial training concerning the incident cause for all project personnel, and proposed prevention and remedial training for all supervisors regarding their responsibility for ensuring that workers are adequately trained prior to use of assigned equipment.
- Contractor investigators were concerned that the nature of the failure and a previous pipe break suggest a degraded fire suppression system in need of rehabilitation, and recommended that engineering personnel should certify the physical condition of the building fire suppression system.
- The ruptured drain line emptied down a sewer storm drain that the contractor believed should have been plugged before the start of D&D activities. Work Control procedures should be revised to require verification of floor drain status in any area prior to commencing work activities. The contractor Director of Regulatory Affairs suggests that an assessment of prior responsibility for plugging the floor drain be conducted (i.e., whether drains were to be plugged prior to building transfer to the D&D contractor).
- The D&D contractor did not have the authority to secure the water supply to the broken fire suppression system drain line, but had to wait for the response from the ETTP Fire Department. The work plan should be modified to allow immediate response by the contractor.
- The unplugged sewer storm drain that flowed to a stream was a floor drain in a radioactive process building. The contractor plans to recommend to the DOE further action to survey other process buildings for possible floor drains that discharge to storm sewers.

EH Engineers have reported similar occurrences involving clean water leaks in the following Summaries:

- Operating Experience Summary 98-31 reported that on July 29, 1998, at Argonne National Laboratory–East, the facility manager reported that a bridge crane trolley contacted sprinkler system piping, causing the pipe to break and spray water onto the floor. Workers operating the bridge crane were moving the trolley into position to lift a storage container when it hit the sprinkler system pipe. When the bridge crane operator observed water spraying from sprinkler system piping, he stopped the crane, and a co-worker telephoned on-site emergency services. The sprinkler system sent a flow alarm to the fire department. Fire department personnel responded promptly and closed the riser valve. There was no physical damage to the crane and no water damage. (ORPS Report CH-AA-ANLE-ANLEPFS-1998-0006)
- Operating Experience Summary 93-40 reported that on September 20, 1993, an operator at the Los Alamos National Laboratory Omega Site discovered water flowing from the vents of three waste tanks onto the ground approximately forty feet from a running stream. The tanks, normally used to store water drained from a reactor coolant system and located underground within a radiological controlled area, were overfilled through a building drain by water leaking from a failed gasket on a potable water back-flow prevention device. Preliminary samples of water from the stream indicated no detectable activity. (ORPS Report ALO-LA-LANL-EGASITE-1993- 0006)

KEYWORDS: Fire suppression system, scissors lift, water leak

FUNCTIONAL AREAS: Decontamination and Decommissioning

4. WATER LINE DAMAGED WHILE EXCAVATING

On May 9, 2000 at Savannah River, the site power crew accidentally cut into an underground 6-inch PVC water line during installation of guy anchors for power line poles. A ground-penetrating radar (GRP) survey had previously identified all the underground utilities, including the water line, and marked them with red flags and paint marks on the ground. The power crew stopped work and notified the facility manager, who further informed the Site Utilities Division about the water line breach. The resulting loss of pressure in the water line caused disruption to a number of site operations. Improper construction practices can seriously impact safety-related critical systems and endanger personnel safety and health. (ORPS Report SR--WSRC-CMD-2000-0009)

The workers used a power auger instead of the required hand digging in the vicinity of the marked utilities and inadvertently ruptured the water line. Investigators determined that water pressure was lost in the Consolidated Incinerator, Tritium Facility and H-B Line. The low water pressure interfered with normal operations, including cooling water to air compressors and chillers. The HB-Line facility manager ordered the process air primary and backup compressors shut down to prevent damage resulting from dead ending on closed dampers. The facility manager also stopped breathing air compressors and placed the facility in a limiting condition of operations (LCO). High Volume Air Activity Monitor (HVAAM) exhausters were also shut down, requiring implementation of respiratory protection procedures. All non-essential personnel were moved from Radiological Buffer and Contamination Areas to office areas due to the shut down HVAAMs. The Site Utilities Division restored the water line in an hour or so. Radiological surveys in the facility indicated no air contamination so respiratory protection requirements were lifted. The LCO for the process air compressors was lifted and the facility returned to normal operations.

Investigators determined that between April 26 and May 8, the responsible construction discipline engineer performed a system walk-down with a sketch that indicated the layout of the survey interferences. Investigators discovered that this field map was not included in the Work Package. Investigators also determined that the Work Clearance Permit of the Work Package identified “Excavation” work, which provides a reference to instructions for digging around the marked utilities, but the workers overlooked that requirement. Investigators further found that the work crew did not perform hand digging to expose all underground utilities that needed protection in the construction area.

Investigators identified the following breakdowns of the Integrated Safety Management system.

- **Hazard Analysis.** The potential loss of domestic water and its impact on facility operations were not adequately considered nor understood during work planning.
- **Implement Controls.** Controls to mitigate normal hazards associated with excavations, as specified in the site construction safety manual, were not followed. No steps were taken to verify compliance with site-specific requirements or to include additional controls, based on the potential for an adverse impact on multiple operations.

The facility management held a Critique Meeting on May 10, and identified the following corrective actions.

- Issue a work package to repair and flush the broken water line, and verify water quality after restoration of normal service.
- Hand dig to verify actual location of underground lines shown on drawings and Site Maps and locate or verify the absence of any interference by using GPR.
- Review the current protocol for contacting shift operations managers during evolutions or events impacting or with a potential to impact facility operations, emphasizing the inclusion of all affected divisions and facilities.
- Ensure that the site’s Excavation Procedures are required reading for all personnel tasked with digging operations.
- Lessons Learned were developed for presentations during construction and monthly safety meetings and site-wide dissemination.

EH engineers identified some similar events.

- Operating Experience Summary 99-24 reported that on June 9, 1999, at the Los Alamos National Laboratory, laborers struck and penetrated a 3-in.polyvinyl chloride (PVC) line that contained hydraulic lines with a working pressure of 1,400 psi. The hydraulic lines were not damaged, but there were two 1-inch diameter

holes in the PVC conduit. The laborers were excavating for the replacement of the main gate of the Plutonium Handling and Processing Facility. Work planners failed to tell the laborers about the hydraulic lines, which control the position of vehicle entry/exit barriers. Although the hydraulic lines were not damaged, the facility manager designee considered the incident a near miss because the high pressure in the hydraulic system could have resulted in personnel injury. (ORPS Report ALO-LA-LANL-TA55-1999-0035)

- Operating Experience Summary 99-21 reported that a subcontractor backhoe operator punctured a buried 6-inch, 55-psi natural gas line while excavating to install a drain pipe for an electrical vault at the Federal Energy Technology Center. The subcontractor failed to follow procedures that required him to locate the pipeline, mark its location before digging, and use hand tools to locate the pipeline. (ORPS Report HQ--GOPE-FETC-1999-0004)

These events highlight the importance of accurately locating underground utilities for safe construction operations. As-built drawings should reflect the location and depth of each underground utility and service. During and following excavation work, as-built drawings should be revised to indicate correct location and depth. The use of locating equipment such as GPR is very helpful, but these devices too have their own limitations. Construction and project managers can further refine and verify the correct location of utilities through actual walk-downs of the work-site. They should also perform pre-construction hazard analysis and implement safety controls to ensure personnel safety during project execution.

Following are some references that provide safety guidelines for facility managers, program and project managers, and project personnel during work involving excavation.

- 29 CFR 1926, *Safety and Health Regulations for Construction*, provides guidelines for employers regarding their responsibilities for identifying underground hazards near the work area.
- DOE/EH-0541, Safety Notice 96-06, *Underground Utilities Detection and Excavation*, includes additional descriptions of excavation events. It describes technology for underground utility detection, specific recommendations for improving excavating programs, and innovative practices used at DOE facilities. The notice states that a central coordinator should not only assist in identifying underground utilities but should also record the findings. The notice also cites three principal causes of excavation and digging occurrences: (1) failure to detect underground utilities because of reliance on as-built drawings; (2) failure to use hand-digging because of the pressure of schedules; and (3) failure to detect underground utilities because detection devices were not used or were used ineffectively.
- OSHA Web site for trenching and excavation at http://www.osha-slc.gov/SLTC/trenchingexcavation/index.html

KEYWORDS: construction, excavation, underground, utility

FUNCTIONAL AREAS: Construction, Industrial Safety, Work Planning, Hazard Analysis

5. UNPLANNED ENTRY INTO CONFINED SPACE COMPROMISES PERSONAL SAFETY

On May 2, 2000 at Oak Ridge, a machinist made an unapproved entry into a confined space (HEPA filter housing) to install new brackets during a scheduled maintenance. The worker was wearing full personal radiation protective equipment and a full-face air-purifying respirator, and had an attending companion, but was not using a retrieval harness. Entry into a confined space without proper planning can lead to hazardous personnel safety consequences. (ORPS Report ORO- -BJC-Y12WASTE-2000-0006)

Line management discovered the unauthorized entry of the worker when the craft crew was beginning to install new brackets. The subcontractor's site safety representative, with agreement from the prime contractor's safety advocate, suspended the job for a safety critique. Line management also directed the work supervisors to re-plan the job, to revise the work package for a confined space entry task, and to include additional safety procedures to ensure personnel safety.

On April 28, 2000 the maintenance supervisor met with the work crew and reviewed the scope of the job for HEPA filter housing bracket replacement. They specifically reviewed the activity hazard analysis, requirements of personal protection equipment, heat stress potential, worker signals for distress, materials and parts needed. On May 1, the supervisor and all essential personnel held a pre-job briefing at the task location, but postponed the start of the job until the next day because of a delay in preparation of the work package and excessively hot weather. On May 2, the work team began work, installed an air sampler in the work area to monitor for radionuclides, and removed the HEPA filter doors. The air sampler indicated radiological and oxygen levels within approved limits. The work package required the crew to remove some existing bolts to provide space for a new bracket without completely entering the filter housing. DOE line management noted the safety infraction when the worker made full entry into the housing to facilitate removal of the old parts. Line management communicated DOE's concerns to the contractor's supervision. The subcontractor's site safety representative, with concurrence from the prime contractor's safety advocate, halted the job and conducted a critique meeting to address safety concerns of the DOE facility representative, subcontract employees and his own. They identified the following corrective actions in conjunction with the DOE facility representative.

- Reclassify entry into the exhaust unit as confined space work and issue an approved confined space work permit.
- Specify more details in the work package for confined space entry requirements, such as personal protection equipment and rescue efforts during emergencies.
- Reinforce adherence to radiological control boundaries to control contamination.
- Review confined space work procedures with workers for any conflict of interpretation.

Investigators determined that the machinist was a trained and qualified confined space worker, fully protected with personal anti-contamination equipment and backed by a companion worker, but was not equipped with a retrieval harness. Investigators also discovered that the machinist used his own discretion in fully entering the HEPA filter housing for better access to the work area, which was not addressed by the work package. This safety infraction compromised his personal safety.

EH engineers identified a number of similar occurrences. The following are some examples.

- Operating Experience Summary 98-28 reported that on July 7, 1998, at the Savannah River Site, H-Tank Farm operators notified F-Tank Farm operators during a daily conference call that they had identified a confined space entry violation that could also be occurring at F-Tank Farm. F-Tank Farm facility managers ordered a review of confined space permits and discovered that their operators had also violated confined space entry procedures. F-Tank Farm operators made four entries into a confined space while air piping in the space was under pressure in violation of procedural guidance in the site safety manual.(ORPS Report SR--WSRC-FTANK-1998-0015)
- Operating Experience Summary 97-46 reported that on November 4, 1997, at the Mound Plant, a power-house stationary engineer entered a power house boiler without satisfying the requirements for confined space entry. The engineer exited the boiler when instructed to do so by industrial safety and health personnel. Facility management immediately stopped work on the boiler. On November 12, 1997, at the Weldon Spring Site, two subcontractor employees entered an open top tank in violation of confined space entry requirements. (ORPS Reports OH-MB-EGGM-GMATO5-1997-0005 and ORO--MK-WSSRAP-1997-0016)

These incidents highlight the importance of strict adherence to confined space procedures for ensuring personnel health and safety. Failure to follow confined space requirements could result in injury or even death. The following documents provide guidance on practices and procedures for safe confined space entry.

- OSHA Standard 29 CFR 1910.146, *Permit-Required Confined Spaces.*
- DOE/EH-035P, OSH Technical Reference Manual, Chapter 4, *Confined Space Entry.*
- DOE-STD-1098-99, *Radiological Control Manual.*

KEYWORDS: confined space entry, work package, pre-planning, radiological monitoring

FUNCTIONAL AREAS: Industrial Safety, Radiological Protection, Training and Qualification

6. WORKER INJURED BY SHIFTING LOAD

On May 1, 2000, at Savannah River, a crane operator was injured when a mixer mast rolled while being loaded onto the deck of a truck by a forklift. A mixer mast is a steel support that extends down into a waste tank to support a mixing motor and impeller. The forklift tines tilted while loading the second of the two masts, which rolled and pinned the crane operator's leg between the masts. The crane operator sustained a severe laceration that required twenty-two stitches. The operator returned to work with crutches that same day. Failure to perform an appropriate job hazard analysis can place workers at risk of serious injury. (ORPS Report SR--WSRC-CSWE-2000-0011)

Two 48-foot long mixer masts were bring loaded onto a flatbed truck at the Central Shops facility. (See Figure 1.) One mixer mast had already been loaded and a second was being loaded with a forklift. Each mixer mast weighed more than 5,000 pounds. The job foreman supervised the loading of the first mixer mast and then left the area to attend to collateral duties. The unsupervised crane operator stood on the bed of the truck next to the loaded mast. The second mast shifted when the tines of the forklift tilted, and it rolled as it contacted the truck bed, pinning the crane operator's leg between the two masts. The crane operator was driven by ambulance to the Savannah River A-area infirmary where the wound was stabilized. The operator was then driven to University Hospital for x-rays and stitches. No fractures were found and, after treatment, the operator was released and returned to work.

Figure 6-1. Mixer Masts on Flatbed

Investigators determined that the forklift driver failed to recognize the hazard created by tilting the forks supporting the unsecured mast while the crane operator was standing directly in the path of the oncoming mast. Management had not prepared a job hazard analysis for loading and unloading irregularly shaped pieces of equipment like the

mixer masts. The work plan did not identify possible types of flatbeds for this job or similar jobs. A crane lift may have been more appropriate than the unstable forklift. Investigators believe the root cause of the incident was the crane operator placing himself in harms way and management allowing the risky behavior to be a part of the job task during the loading process.

A number of corrective actions were proposed.

- An evaluation should be performed to identify the appropriate equipment to use for this type of job;
- An evaluation should determine the type of cribbing to use for this type of job or similar jobs;
- A job hazard analysis for a truck loading operation should include flatbed height and be part of the work planning process;
- 29 CFR 1910.178 m and o (*Truck Operations* and *Loading*, respectively) should be integrated into the Training and Rigging Procedures.

EH Engineers have reported similar occurrences involving worker injuries in the following Summaries:

- Operating Experience Summary 99-43 reported that on June 23, 1999, at the Oak Ridge National Laboratory, a worker in a waste storage area was struck on the arm by a remote-handling device, causing a laceration that required nine stitches. The device was designed for replacing a retrieval lanyard on a spent nuclear fuel canister. As workers performed a practice run of positioning the device and replacing the lanyard, a cable holding the device slipped off a lifting post and the device fell, cutting the worker's arm. (ORPS Report ORO--BJC -X10WSTEMRA -1999 -0001)
- Operating Experience Summary 98-22 reported that on May 15, 1998, at the Oak Ridge National Laboratory Y-12 Nuclear Operations Facility, a boom fell, struck a maintenance worker, and pinned one of his fingers to a railroad tanker car when a hoisting cable broke. Investigators determined that the cable, which was not weatherproof, had been exposed to weather elements over a 10-year period, and no one inspected it before the operation began. (ORPS Report ORO--LMES-Y12NUCLEAR-1998-0044)
- Operating Experience Summary 97-03 reported that on January 7, 1997, at the Fernald Environmental Management Project, a piece of steel conduit approximately 3 feet long and 1-1/2-inches in diameter was ejected from scrap metal being lifted by a hydraulic grappling unit and struck a worker in the back. The worker was spraying water on a pile of metal to minimize dust and was standing 30 feet from the pile. He suffered a contusion to the lower left quadrant of his back. (ORPS Report OH-FN-FDF-FEMP-1997-0004)

KEYWORDS: Mixer mast, flatbed truck, forklift, job hazard analysis

FUNCTIONAL AREAS: Powered Industrial Trucks, Hoisting and Rigging, Worker Safety

7. TRENCHING ACTIVITIES VIOLATE OSHA AND LABORATORY STANDARDS

On April 25, 2000, at Los Alamos, facility management stopped trenching activities when a site safety representative reported significant concerns. Excavators dug a trench in excess of 10 feet deep to locate a fire suppression system leak. The safety representative advised the project supervisor to stop further trench work when he noticed that proper shoring and other safety measures were not in place. Facility management held a critique meeting to discuss the incident and formulate corrective actions. There were no injuries associated with this event. (ORPS Report ALO-LA-LANL-TA55-2000-0010) A second event occurred at Brookhaven on May 16, 2000, when a plant engineering employee excavated around a storm drain to repair storm drainage lines. A site superintendent and a general supervisor stopped all work when they noticed that the excavation was 7.5 feet deep and had inadequate cave-in protection. Facility management placed a moratorium on the project until the violations were corrected. There were no injuries resulting from this event. (ORPS Report CH-BH-BNL-PE-2000-0002)

Investigation is ongoing for the Los Alamos occurrence. In the Brookhaven event investigators determined that the plant engineering employee violated a laboratory standard that was more stringent than the Occupational Safety and Health Administration standard. They determined that the employee worked in the excavation without adequate cave-in protection and without laboratory required oversight.

EH engineers identified the following events involving trenching violations.

- Operating Experience Summary 99-09 reported two events at Savannah River New Tritium Support Facility: On January 19, 1999, two workers entered a trench that was approximately 6 feet deep and was not sloped to suit the soil condition. On February 17, 1999, an employee was taking measurements in a trench more than 5 feet deep that was neither shored nor properly sloped to prevent cave-in. Each occurrence exposed employees to potential risk. (ORPS Reports SR--WSRC-CMD-1999-0001 and SR--WSRC-CMD-1999-0002)
- Operating Experience Summary 96-35 reported that on August 20, 1996, at the Brookhaven National Laboratory, a plant engineering construction safety specialist making routine rounds of construction activities found subcontractor employees working in an unsafe excavation. The excavation was over 5 feet deep and without cave-in protection. There was a spoil pile at the edge of the excavation, and in some areas the soil was 10 feet above the workers. (ORPS Report CH-BH-BNL-PE-1996-0015)

These occurrences underscore the importance of establishing and enforcing an effective excavation safety program. Although the violations at Los Alamos and Brookhaven seem minor, worker safety depends on strict compliance with established standards. Excavation cave-ins cause serious and often fatal injuries to workers each year and excavation is recognized as one of the most hazardous of construction operations. The Bureau of Labor Statistics suggests that cave-ins cause approximately 1,000 injuries in the United States each year. Of 1,107 construction industry deaths reported in 1997, 50 were related to excavation work. OSHA Standard 29 CFR 1926, subpart P, *Excavations*, was developed by analyzing excavation accidents and identifying effective preventive measures. It provides worker protection requirements for sloping, benching, shoring, and shielding excavations more than 5 feet deep. DOE has incorporated this subpart into its construction safety program for all contractors.

OSHA recently revised subpart P of 29 CFR 1926 to make the standards easier to understand, to permit the use of performance criteria where possible, and to provide construction employers with options when classifying soil and selecting employee protection methods. OEAF engineers recommend TED 1-O.15A, OSHA Technical Manual, as a valuable compliance and training supplement to OSHA standards. Section V, chapter 2, *Excavations: Hazard Recognition in Trenching*, provides a summary of the OSHA regulations governing excavation safety. It is intended to assist safety professionals in recognizing and preventing trenching and shoring hazards. The entire OSHA technical manual is available at http://www.osha-slc.gov/dts/osta/otm/otm_toc.html.

Facility operators need to exercise sufficient oversight to ensure that subcontractors comply with safety requirements. Subcontractors will take safety requirements more seriously if they realize that frequent or flagrant violations result in loss of revenue, permanent dismissal, or preclude future contracts. Workers need to realize that safety requirements are developed to protect them, not simply to satisfy requirements. In general, DOE prime contractors have satisfactorily incorporated OSHA requirements into site and facility construction and procurement programs. However, safety violations continue to occur throughout the complex, principally among subcontractors, for reasons that are difficult to determine. Subcontracted construction workers come from a variety of backgrounds, and some have not adopted the level of safety consciousness required of DOE contractor and subcontractor employees. The subcontractor involved in the infractions at Savannah River is experienced generally, but has limited experience with the DOE safety culture.

KEYWORDS: trenching, OSHA, shoring, sloping, excavation, safety, violation

FUNCTIONAL AREAS: Industrial Safety, Hazards and Barrier Analysis

OEAF FOLLOW-UP ACTIVITIES

1. FOLLOW-UP OF VENTILATION DUCTING CRACKS

EH engineers reviewed a final occurrence report of a February 8, 2000 incident at Hanford, where B Plant Canyon replacement exhaust system ducting was found cracked. (Operating Experience Summary 2000-04) The system was shut down within a few hours of the discovery and reported to the State of Washington Department of Health. At the time of the discovery, the system was being operated in a low-flow configuration for aerosol testing on one of the filtration units. A radiological survey did not detect any contamination outside the ducting. (ORPS Report RL--PHMC-BPLANT-2000-001)

Investigators determined that the ventilation system had recently been installed to replace a system that had previously developed cracks. (ORPS Report RL--PHMC-BPLANT-1999-0003) The replacement ducting was placed in service on February 7, 2000 and on the following day two new cracks were discovered and the system was shut down.

A ventilation system specialist, contracted to perform ventilation characterization, determined that the cracking was due to excessive vibration, which led to fatigue failure of the duct. Vibration and structural dynamic testing of the fans and exhaust ductwork associated with the B Plant Canyon Exhaust System was conducted by measuring dynamic pressure pulsations and resonance frequency of the exhaust fans and ductwork at different flow rates. The amount of air flowing through the exhaust system was adjusted by modulating the fan inlet vane damper. The source of the vibration was pressure pulsations from a rotating stall condition in the fan wheel. The vibration measured in the exhaust duct panels at 15,000 scfm was within the acceptable range for system operation; however, vibration increased as the flow was reduced. At 13,500 scfm, rotating stall was not a problem, but the vibration levels in the duct increased due to the turbulence level within the duct. At 11,500 scfm a rotating stall began and vibration level increased significantly as the flow was lowered. At 8,800 scfm, the frequency of the rotating stall excited the natural frequency of the exhaust duct to levels that resulted in premature duct failure.

Another test was conducted to investigate fan stall sensitivity to control damper location. The fan inlet vane was set to full open and the airflow through the system was controlled via the Air Cleanup Train (ACT) discharge isolation butterfly valves allowing a flow rate of 7,600 scfm. The fan operated in a complete stall, but vibration levels in the duct were reduced dramatically because the duct was not sensitive to the frequency of the stall pressure pulsations.

Corrective actions included:

- Weld repair the two cracks and retest the duct for leaks.
- Relocate/reconfigure 2 test fittings to reduce duct vibration.
- Change operating procedures to avoid operation in critical airflow ranges.

The following lesson learned was identified from the investigation.

- Vibration analysis should have been included as part of the initial testing of the replacement ductwork after installation to provide insight into the direct cause of the cracking. This would have avoided the failure of the replacement ductwork and provided operational restraints to the system.